Application of non Parametric Life Tests on Reliability

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Abstract

This work consists to study the reliability of the vehicles of the Logitrans unit of Bejaia. Pareto analysis permitted to select the most fragile elements (very elevated maintenance cost and elevated number of breakdowns). Two classes of vehicles have been kept. These last have been divided in subsystems. The life distribution of the subsystems of every class were modelised, from TBF (Time between Failure), raised of the data feedback experience. Two models have been used: a parametric model (weibull with two parameters) and a non parametric model (A_2 test of Klefsj). For every class of vehicle, three types of subsystems have been gotten: IFR, exponential and DFR subsystems.

Introdution

To every development of the economic activity corresponds a growth of the demand of transportation and its efficiency in term of cost, delays, availability, comfort and security. Estimate the reliability of a material in exploitation is one of the most important preoccupations of this enterprise because it reveals weakness that put it unavailable. The return experience has the advantage to provide the data come from the land, taking in account all factors who, can influence on the safety of working of the material. The objective of this work is precisely to present a methodology of analysis and treatment of data of the return of experience relative to failings of vehicles of the rolling park of the Logitrans unit of Bejaia to take decision concerning maintenance (to optimize costs of the maintenance, to detect the, components that require a preventive renewal and to determine the optimal periodicity of that renewal, ...) and the improvement of the vehicle availability.

1 Collecte and constitution of sample data

The park of the Logitrans unit of Bejaia is composed of 31 vehicles (tractors) in good state:

- 21 vehicles of type TB 305 of SNVI mark put in exploitation in 1987;
- 3 vehicles of type TB 340 of SNVI mark put in exploitation in 1997;
- 5 vehicles of type TB 325 of SNVI mark put in exploitation in 1999;
- 2 vehicles of VOLVO type of N10 mark put in exploitation in 1977.

The collection of data of the experience return within the Logitrans unit of Bejaia has been made by the analysis of the archives of the service maintenance (registers receipt, registers of maintenance, registers of stocks ...), and that, for the period from 01/01/2001 to 30/04/2003. The information contained in these data are ambiguous and present some imprecisions. These data are necessary to value reliability and the availability of vehicles. The variable that will constitute our samples are the Time Between two Failure). The ABC analysis (Pareto analysis) permitted to determine vehicles that are most expensive in maintenance. It is 8 vehicles of type TB 305 and 3 vehicles of type TB 325 that caused 50.33 % of costs of maintenance during the period studied with solely 39.50 % of the total number of breakdowns.

Table 1: Vehicles come out by ABC analysis

Code	Type	Year of first exploitation
00Z D212	TB 305	1987
00Z D218	TB 305	1987
00Z D219	TB 305	1987
00Z D213	TB 305	1987
00Z D510	TB 325	1999
00Z D221	TB 305	1987
00Z D186	TB 305	1987
00Z D511	TB 325	1999
00Z D225	TB 305	1987
00Z D337	TB 305	1987
00Z D512	TB 325	1999

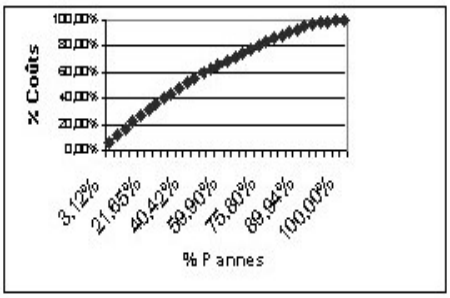

Figure 1: Curve of ABC analysis (Pareto analysis)

2 Analyse of vehicle reliability

A decomposition of these vehicles in subsystems has been achieved in order to detect their weak elements. Every subsystem can represent only one component as well that about ten or same about hundred components. The Subsystems concerned by this study are:
1. alimentation and injection system; **2.** water cooling system; **3.** electric System; **4.** direction system; **5.** air braking system; **6.** transmission system; **7.** lubrication system; **8.** admission system; **9.** exhaust system; **10.** clutch system; **11.** Motor.
An analysis of the system reliability composing these vehicles has been achieved by two modellings: parametric modelling which consists to adjust data by the Weibull distribution of two parameters because it have the particularity to modelize the three phases of the life of a material (youth, maturity, old age), validated by Kolmogorov-Smirnov test and Khi-Two test and non parametric modelling with non parametric life distributions (IFR (DFR), ...) like graphic test and the A_2test, of Klefsj. This analysis permits of:

- Determine their operational behaviors;
- Determine the evolution of their failure rates;
- Locate systems that contribute to the reduction of the vehicle availability generated by their breakdowns, what generates important losses of production (losses of benefits of service) and whose can damage the reliability of the vehicle;

- Study the elements of the system which cause an important number of breakdowns and the increase of costs;
- Choice and adequate maintenance policies and to optimize costs of the maintenance.

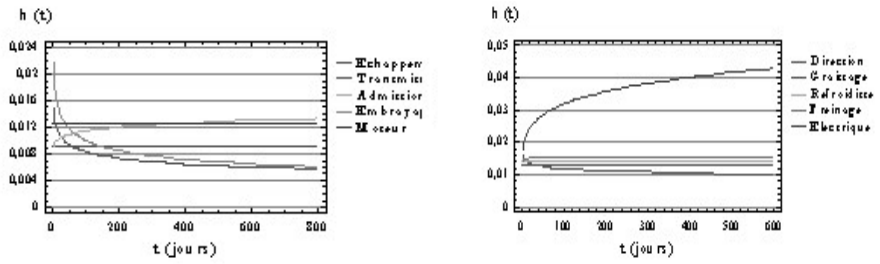

Figure 2: Failure rates of the systems of the vehicles of type TB 305

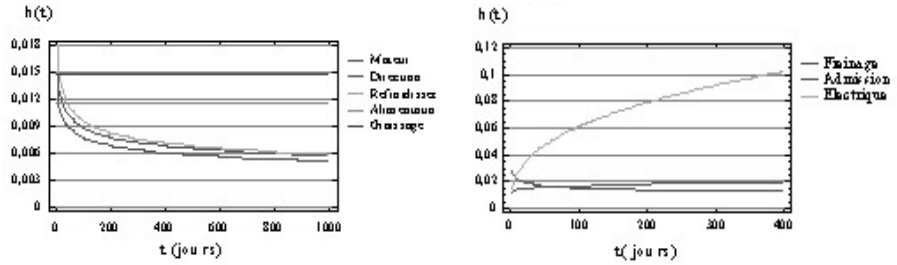

Figure 3: Failure rates of the systems of the vehicles of type TB 325

The aimed objective is the detection of the growth of failure rate to consider the application of the preventive maintenance. This last is applied while taking in account the economic criteria (failure cost and maintenance cost). The comparison of reliability indicies of subsystem revealed that some among them are subject to fatigue failures it is more precisely about the electric system, braking and admission system of TB 305 class and of the electric system, braking of TB 325 class. It permits to affirm that these components deteriorate by ageing (increasing failure rate). it permitted to detect the least reliable systems, and that, as comparing their MUT, their reliability functions and their failure rates $\lambda(t)$.

The modelling of the behavior of every class of vehicle made come out again that vehicles of type TB 325 are on average more reliable than those of type TB 305.

3 Renouvellement and Availability

Now, one is interested to study economic of the renewal. One analyzing the aging sub systems (electric system, braking and admission for the class TB 305 and electric system and braking for the class TB 325) in maintenables elements. Pareto analysis give more expensive elements in maintenance. These last caused 86.6 % of total costs of maintenance during the period of observation with uniquely 37 % of the total number of breakdowns. The economic study of renewal of these elements watch that the preventive renewal is not economically profitable. The study of the vehicle availability permits to know factors, among reliability, the maintenability (MTTR) and the logistics of maintenance (stocks of spare parts, time appendices of repair.), that influential on the availability. After the adjustment of TBF, of repair times and stop times, one first has calculate the real availability of every vehicle, while taking in account of immobilizations, noted $D_1 = (MUT)/(MUT + MDT)$ then, one has calculate the availability

one let's consider that times of repair, noted $D_2 = (MUT)/(MUT + MTTR)$. Then, one valued the unavailability $(D2 - D_1)$ driven by times of waiting of the spare part.

Table 2: Avaibility of the vehicles

Class	MUT (hour)	MTTR (hour)	MDT (hour)	D_1	D_2	$D_2 - D_1$
TB 305	359.49	13.747	59.116	0.858	0.963	0.105
TB 325	384.456	5.823	18.55	0.953	0.985	0.032

Thus, the availability of vehicles of type TB 325 is raised more that the one of vehicles of type TB 305. By elsewhere, the average time of repair of these last is superior. Therefore, vehicles of type TB 325 are more capable to be maintained. This study also permitted to note that the waiting time du to the lack of spare parts is the main factor that influences on the availability of vehicles. The improvement of the availability would require a better hold in charge of maintenance means, notably, the revision of the policies of the management of stocks of the spare part, what will permit of to reduce times of immobilization considerably.

Conclusion

The analysis of data of the return of experience of vehicles of the Logitrans unit of Bjaia has been made in several stages. The ABC analysis (of Pareto) permitted to detect the most fragile elements. These last constitute the studied sample. The studied vehicles have been decomposed in subsystems. A parametric and non parametric modelization of the reliability of these last has been done to detect the more fragile elements in order to foresee the adequate maintenance policies. The economic study of renewal has revealed that the preventive maintenance is not economically profitable. Otherwise, the availability of the vehicles of type 325 are raised more that the one of type 305 vehicles. It is important to signal that the waiting time of the spare part is the main factor that influences on the availability of vehicles.

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